Design Solutions for Vapor Intrusion and Indoor Air Quality

EPA's Brownfields Program is designed to empower states, communities, and other stakeholders in economic redevelopment to work together in a timely manner to prevent, assess, safely clean up, and sustainably reuse brownfields. A brownfield is a property, the expansion, redevelopment, or reuse of which may be complicated by the presence or potential presence of a hazardous substance, pollutant, or contaminant. EPA's Brownfields Program provides financial and technical assistance for brownfields revitalization, including grants for environmental assessment, cleanup, and job training.

Purpose

This fact sheet provides an overview of technical and health issues regarding chemical vapor intrusion into indoor air, and how to address these issues to foster land redevelopment. This document will discuss how to:

- anticipate the potential for vapor intrusion;
- evaluate the extent of the problem; and
- prevent or correct the problem.

Background

EPA's mission is to protect human health and to safeguard the natural environment. Part of achieving this mission includes evaluating sites for contamination and the risk it potentially poses to people and the environment.

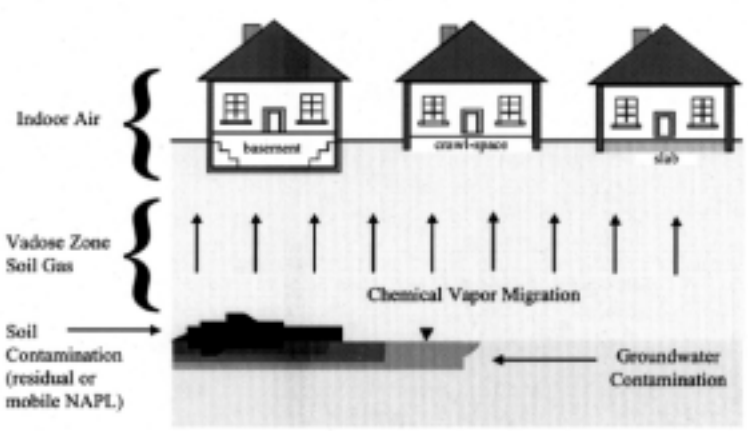
As redevelopment of cleaned-up sites becomes more prevalent, assessment and elimination of contamination risks is crucial. Quantifying and eliminating these risks includes assessment of the exposure pathways. Exposure pathways are the ways that people can be exposed to contamination such as breathing contaminated air, drinking contaminated water, or touching contaminated soil. Vapor intrusion is one exposure pathway that can cause potentially serious risks if left unaddressed.

What is Vapor Intrusion?

Vapor intrusion is the entry of a specific type of contaminant, volatile organic compounds (VOCs), to indoor air from underlying contamination in soil and groundwater. VOCs readily disperse into air — even into the small air spaces within soil and underneath a structure.

Indoor air pollution detected at a site may not necessarily be a result of vapor intrusion. Background or preexisting levels of contaminants may be present from chemical use in the building or from ambient air. It is often difficult to distinguish between contamination attributable to vapor intrusion and contamination due to background levels. Regardless, the risk caused by vapor intrusion should be investigated and quantified if it is suspected.

The Vapor Intrusion Pathway



Vapor Intrusion Need Not Hinder Redevelopment

Although vapor intrusion is a serious concern, it need not be an impediment to redevelopment. Vapor intrusion problems can be properly addressed through investigating the history of site activity, and the nature and extent of contamination. Depending on the phase of redevelopment and whether existing structures will be renovated or new buildings will be erected, vapor intrusion can be prevented or corrected. It is often more protective of human health and the environment and more cost effective in the long run to eliminate the contamination if possible.

Anticipating the Potential for Vapor Intrusion

Certain hazardous waste sites are more likely to cause vapor intrusion problems than others. Vapor intrusion is typically associated with petroleum products and chlorinated solvents or other VOCs in soil and groundwater. Accordingly, the vapor intrusion pathway should be investigated at sites with or near this type of contamination. VOCs are often associated with former gas stations, bus stations, dry cleaning and laundering facilities, automotive repair shops, and other sites where petroleum products or solvents were stored, handled, or transferred and had the potential to be spilled.

Certain environmental conditions such as a high water table (short depth to groundwater), some types of soils, and fractured bedrock can increase the likelihood of intrusion. Coarsely grained soils allow contamination to migrate longer distances more quickly and escape more readily to the atmosphere. The close spacing of finely grained soils allows for greater upward movement of liquid, a process called capillary action, which may bring contaminated groundwater closer to the building. Contaminants are generally unable to move through very fine soils such as clay, except in cases where vertical fractures are present in these soils.

VOCs can seep through foundation cracks, holes in concrete floors, and small gaps around pipes and utility lines. The age of a structure's foundation, its floor construction, and the existence of drain and tile sumps can also contribute to vapor intrusion. Vapor intrusion can occur in buildings with or without basements.

Some vapors, such as VOCs, may enter structures at low contamination levels, and building ventilation systems may prevent harmful vapor buildup. In other cases, chemicals may accumulate in buildings at concentrations high enough to create fire and explosion hazards. In addition, VOCs may or may not have a noticeable odor and may be present at levels posing acute or chronic health risks. EPA suggests evaluating vapor intrusion when a site has, or is near, contaminated soil or groundwater.

Evaluating Vapor Intrusion

EPA has developed a Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (www.epa.gov/correctiveaction/eis/vapor.htm). Research on vapor intrusion is rapidly developing, and this guidance represents EPA's latest recommendations on this evolving subject. EPA received many comments on the guidance and anticipates continued updates to its content. The current guidance details a three-tiered approach to evaluating the vapor intrusion pathway: Primary Screening, Secondary Screening, and Site-Specific Pathway Assessment. Each tier contains a set of questions to guide the user towards a determination of whether the vapor intrusion exposure pathway is complete and if so, presents unacceptable risks.

The guidance also provides contaminant concentration levels to help screen for soil and groundwater conditions in residential settings. Screening level concentrations appropriate for commercial settings may be developed according to the procedures outlined in Appendix D of the guidance.

Modeling tools may assist in the evaluation of the vapor intrusion threat, but any model used should take into account site-specific conditions. Typically, these models allow the user to examine a range of possible site conditions and a subsequent range of resulting impacts. One of the most commonly used is the Johnson and Ettinger (1991) Model for Subsurface Vapor Intrusion Into Buildings, available on EPA's web site (www.epa.gov/superfund/programs/risk/airmodel/johnson_ettinger.htm). EPA's version of this model is designed to produce data appropriate for residential settings. To apply this model to commercial settings, data parameters should be checked and revised as appropriate. Modeling is a helpful tool when combined with site investigation and risk assessment, but does not serve as a sufficient evaluation of the vapor intrusion pathway alone.

Preventing Vapor Intrusion

Steps can be taken before site redevelopment to prevent vapor intrusion. Some examples of prevention include: ensuring that VOC contamination is removed from the site (and sent to a proper treatment and disposal facility); preventing upward contaminant migration with an impermeable barrier such as a clay cap; and venting soil gas to outdoor air before it can reach indoor spaces.

The local community should be notified of and involved in the redevelopment process to allow citizens to express their concerns and expectations regarding how to address the cleanup of the source of the vapor intrusion. More information on community involvement in site cleanup and redevelopment, and how communities can get expert help in making decisions about cleanup in their neighborhoods, can be found at: www.epa.gov/superfund/tools and www.toscprogram.org.

Correcting Vapor Intrusion

Source removal is the most thorough way to prevent a vapor intrusion problem. However, source removal may not address immediate risks, be cost effective, be well suited to site redevelopment, or be possible. At sites where the source of contamination cannot be completely eliminated, other solutions to vapor intrusion problems can be implemented. Building techniques that serve to provide a vapor barrier between interior spaces and soil (or groundwater) can be combined with structures that provide an escape route for soil vapor to vent to the atmosphere rather than into indoor air. It may be possible to add ventilation systems to existing buildings and to seal entrances for vapors such as foundation cracks, holes in concrete floors, small gaps around pipes and utility lines, and sumps. Some ventilation systems operate effectively without the use of energy, while others may require connection to a power supply.

Correcting indoor air quality problems may only require passive systems — those that increase ventilation by providing an escape route for vapors to vent to the outdoors. When air quality levels present an unacceptable threat to human health, active systems that create and maintain flow from indoor air spaces to the outside through use of fans or blowers may be more appropriate. Such systems must be designed so that vented air is not drawn back into other air intake systems or windows. Furthermore, designs that are effective for solving vapor intrusion problems in commercial buildings may not be appropriate for residential dwellings.

After taking steps to block the vapor intrusion pathway, a plan should be developed to ensure that these steps are working correctly. This plan should include monitoring air quality and the operation of any ventilation systems. Many systems designed for correcting radon gas problems are effective for vapor intrusion. More information on these systems can be found at www.epa.gov/radon and additional sources of information regarding remediating contaminated soil and groundwater at hazardous waste sites can be found through a search of the main site — www.epa.gov.

Elimination of the threat of fire or explosion associated with vapor intrusion should involve measures to stop gas migration as far from structures as possible. The buildup of volatile compounds underneath or adjacent to buildings may not present the risk of acute or chronic health effects, but may threaten to ignite.

For sites where vapor intrusion problems originate with contaminated groundwater, steps should be taken to prevent entry of water to subsurface building levels. As with soil vapor entry problems, preventing seepage of water into basements and subsurface structures includes sealing cracks and holes in foundations and ensuring that sump systems are functioning properly. Groundwater remediation techniques are numerous, including pump and treat systems, permeable reactive barriers, air sparging, vertical containment barriers, and in-situ bioremediation. Different remediation methods may be more suited to certain site-specific circumstances. For more information on these and other groundwater remediation techniques, consult the references in the "For More Information" section and visit EPA's web site at www.epa.gov/tio/remed.htm.

For More Information

Draft Guidance for Evaluating the Vapor Intrusion to Indoor Air Pathway from Groundwater and Soils (November 2002)
www.epa.gov/correctiveaction/eis/vapor.htm

Evaluating the Vapor Intrusion into Indoor Air (November 2002)
www.epa.gov/correctiveaction/eis/vapor/f02052.pdf

Groundwater Cleanup: Overview of Operating Experience at 28 Sites (September 1999)
www.epa.gov/swertio1/download/remed/ovopex.pdf

Johnson and Ettinger (1991) Model for Subsurface Vapor Intrusion into Buildings
www.epa.gov/superfund/programs/risk/airmodel/johnson_ettinger.htm

EPA Regional Brownfields Contacts
www.epa.gov/brownfields/contacts.htm

Superfund Community Involvement Toolkit
www.epa.gov/superfund/tools/index.htm

Innovative Remediation Technologies
www.epa.gov/tio/remed.htm

EPA Office of Air & Radiation Radon Site
www.epa.gov/radon

Hazardous Substance Outreach Programs for Communities
www.toscprogram.org